

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Galvanized Ductwork
- B. Ductwork Reinforcement
- C. Ductwork Sealants
- D. Rectangular Ductwork - Single Wall
- E. Round Ductwork - Single Wall
- F. Flexible Duct
- G. Leakage Testing
- H. Ductwork Penetrations

1.02 REFERENCES: Conform to all applicable requirements of the following publications:

- A. ADC Flexible Duct Performance and Installation Standards, 3rd Edition 1996.
- B. California Energy Code - 2013.
- C. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- D. ASHRAE - Handbook 2012 Systems and Equipment; Chapter 19 - Duct Construction.
- E. ASHRAE - Handbook 2013 Fundamentals; Chapter 21 - Duct Design.
- F. ASTM A90 - Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
- G. ASTM A167- Stainless & Heat-Resisting Chromium-Nickel Steel Plate, Sheet, & Strip.
- H. ASTM A653 - Steel Sheet, Zinc-Coated (Galvanized) or zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- I. ASTM A924 - Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
- J. ASTM E90-02 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions.
- K. ASTM E413-87 - Classification for Rating Sound Insulation.
- L. NADCA Standard 05 1997 - Requirements for the Installation of Service Openings in HVAC Systems.
- M. NFPA 90A - Installation of Air-Conditioning and Ventilating Systems.
- N. NFPA 90B - Installation of Warm Air Heating and Air- Conditioning Systems.
- O. SMACNA – Air Duct Leakage Test Manual – 1985 Edition.

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- P. SMACNA - HVAC Duct Construction Standards - 2005 Edition.
- Q. SMACNA - Round Industrial Duct Construction Standards - 1999 Edition.
- R. UL 181 - Factory-Made Air Ducts and Air Connectors.
- S. UL 181A - Closure Systems for Use With Rigid Air Ducts and Air Connectors
- T. UL 181B - Closure Systems for Use With Flexible Air Ducts and Air Connectors.

1.03 SUBMITTALS

- A. Submit shop drawings per Section 23 05 00.
- B. Submit duct fabrication standards in compliance with SMACNA and these specifications. Clearly indicate metal gauges, reinforcement, and joining methods intended for use for each pressure classification. Furnish details of all common duct fittings and joint connections to be used on this project.
- C. The Architect/Engineer may require field verification of sheet metal gauges and reinforcing to verify compliance with these specifications. At the request of the Architect/Engineer, the contractor shall remove a sample of the duct for verification. The contractor shall repair as needed.

1.04 DEFINITIONS

- A. Duct Sizes shown on drawings are inside clear dimensions. Maintain clear dimensions inside any lining.
- B. Transitions are generally not shown in single-line ductwork. Where sizes change at a divided flow fitting, the larger size shall continue through the fitting.

1.05 COORDINATION DRAWINGS

- A. Reference Coordination Drawings article in Section 23 05 00 for required duct systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.
- B. Duct drawings shall be at 1/4" minimum scale complete with the following information:
 - 1. Actual duct routing, ductwork fittings, actual sheet metal dimensions including insulation liner and wrap, duct hanger and support types, ductwork accessories, etc. with lengths and weights noted.
 - 2. Differentiate ducts that are lined or wrapped. Include insulation thickness, type of insulation, and acoustical lagging.
 - 3. Location and size of all duct access doors.
 - 4. Room names and numbers, ceiling types, and ceiling heights.
 - 5. Indicate location of all beams, bar joists, etc. along with bottom of steel elevations for each member.

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- C. KJWW will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by KJWW. KJWW will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings. Architectural plans will need to be obtained from the Architect.

PART 2 - PRODUCTS

2.01 GALVANIZED DUCTWORK

A. General Requirements:

1. Duct and reinforcement materials shall conform to ASTM A653 and A924.
2. Interior Ductwork and reinforcements: G60 galvanized (0.60 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise.
3. Exterior Ductwork: G90 galvanized (0.90 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise. G60 is not acceptable for exterior use.
4. Ductwork reinforcement shall be of galvanized steel.
5. Ductwork supports shall be of galvanized or painted steel. Slip cable hangers are acceptable. Acceptable manufacturers are Gripple, Ductmate, Duro Dyne, or Architect/Engineer approved.
6. All fasteners shall be galvanized or cadmium plated.

2.02 DUCTWORK REINFORCEMENT

A. General Requirements:

1. All reinforcement shall be external to the duct except that tie rods may be used with the following limitations.
 - a. Ducts must be over 18" wide.
 - b. Duct dimensions must be increased 2" in one dimension (h or w) for each row of tie rods installed.
 - c. Tie rods must not exceed 1/2" diameter.
 - d. Manufacturer of tie rod system must certify pressure classifications of various arrangements, and this must be in the shop drawings.

2.03 DUCTWORK SEALANTS

- A. One part joint sealers shall be water-based mastic systems that meet the following requirements: maximum 48-hour cure time, service temperature of -20°F to +175°F, resistant to mold, mildew and water, flame spread rating below 25 and smoke-developed rating below 50 when tested in accordance with ASTM E84, suitable for all SMACNA seal

classes and pressure classes. Mastic used to seal flexible ductwork shall be marked UL 181B-M. Joint sealers for use on exterior weather exposed ductwork shall be rated for -30°F to +175°F and 2000 hour minimum UV resistance per ASTM G-53.

2.04 RECTANGULAR DUCT - SINGLE WALL

A. General Requirements:

1. All ductwork gauges and reinforcements shall be as listed in SMACNA Duct Construction Standards Chapter 2. Where necessary to fit in confined spaces, furnish heaviest duct gauge and least space consuming reinforcement.
2. Transitions shall not exceed the angles in Figure 4-7.

B. Exceptions and modifications to the 2005 HVAC Duct Construction Standards are:

1. All ducts shall be cross-broken or beaded.
2. Turning vanes shall be used in all 90° mitered elbows, unless clearly noted otherwise on the drawings. Vanes shall be as follows:
 - a. Type 1:
 - 1) **Description:** Single wall type with 22-gauge (0.029") or heavier vanes, 3-1/4" blade spacing, and 4" to 4-1/2" radius. Vanes hemmed if recommended by runner manufacturer. Runners shall have extra long locking tabs. C-value independently tested at below 0.26. EZ Rail II by Sheet Metal Connectors or equal.
 - 2) **Usage:** Limited to 3,000 fpm and vane lengths 36" and under.
 - b. Turning vanes shall operate quietly. Repair or replace vanes that rattle or flutter.
 - c. Runners must be installed at a 45° angle. Elbows with different size inlet and outlet must be radius type.
 - d. Omitting every other vane is prohibited.
3. Where smooth radius rectangular elbows are shown, they shall be constructed per SMACNA Figure 4-2. Type RE1 shall be constructed with a centerline duct radius R/W of 1.0. Where shown on drawings, Type RE3 elbows with 3 vanes shall be used with centerline duct radius R/W of 0.6 (SMACNA r/W=0.1). RE1 or RE3 elbows may be used where mitered elbows are shown if space permits. **Mitered elbows (with or without turning vanes) may not be substituted for radius elbows.** Do not make branch takeoffs within 4 duct diameters on the side of the duct downstream from the inside radius of radius elbows.
4. Rectangular branch and tee connections in ducts over 1" pressure class shall be 45° entry type per Figs. 4-5 and 4-6. Rectangular straight taps are not acceptable above 1" pressure class.

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5. Bellmouth fittings shown on return duct inlets shall expand at a 60-degree total angle horizontally and vertically (space permitting) and have length of at least 25% of the smallest duct dimension.
6. Round taps off rectangular unlined ducts shall be flanged conical or bellmouth type (equal to Buckley Bellmouth or Sheet Metal Connectors E-Z Tap), or 45° rectangular with transition to round (equal to Sheet Metal Connectors Inc. High Efficiency Takeoff). Straight taps are acceptable if pressure class is 1" or less, round duct is 12" diameter or less, and the tap is not located between fans and TAB devices.
7. Duct offsets shall be constructed as shown on drawings. Additional offsets required in the field shall be formed of mitered elbows without turning vanes for offsets up to 30° maximum angle in accordance with SMACNA offset Type 2. Offsets of greater than 30° angle shall be formed of radius elbows with centerline radius R/W=1.0 or greater. SMACNA Type 1 offsets are not permitted.
8. All lined duct shall utilize dovetail joints where round or conical taps occur. The dovetail joints shall extend past the liner before being folded over.
9. Cushion heads are acceptable only downstream of TAB devices in ducts up to ± 2 " pressure class, and must be less than 6" in length.
10. Slide-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.
 - a. Apply sealant to all inside corners. Holes at corners are not acceptable.
 - b. Acceptable Manufacturers: Ductmate Industries - 25/35/45, Nexus, Mez, or WDCI. Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer's approval before any fabrication begins.
11. Formed-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.
 - a. Apply sealant to all inside corners. Holes at corners are not acceptable.
 - b. Flanges shall be 24-gauge minimum (not 26 gauge).
 - c. Acceptable Manufacturers: Lockformer TDC, TDF, United McGill, or Sheet Metal Connectors. Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer's approval before any fabrication begins.

2.05 ROUND DUCTWORK - SINGLE WALL

- A. Conform to applicable portions of Rectangular Duct Section. Round or flat oval ductwork may be substituted for rectangular ductwork where approved by the Architect/Engineer.

The spiral seam ductwork shall meet the standards set forth in this specification. The ductwork shall meet or exceed the specified cross-sectional area and insulation requirements. The substitution shall be coordinated with all other trades prior to installation.

- B. Snap lock seams are not permitted.
- C. Flat oval duct in negative pressure applications shall have flat sides reinforced as required for rectangular ducts of the same gauge with dimensions equal to the flat span of the oval duct.
- D. 90° elbows shall be smooth radius or have a minimum of five sections with mitered joints and R/D of at least 1.5.
- E. Duct and fittings shall meet the required minimum gauges listed in chapter 3 of the SMACNA requirements for the specified pressure class. Ribbed and lightweight duct are not permitted.
- F. Ductwork shall be suitable for velocities up to 5,000 fpm.
- G. Divided flow fittings may be made as separate fittings or factory installed taps with sound, airtight, continuous welds at intersection of fitting body and tap.
- H. Spot weld and bond all fitting seams in the pressure shell. Coat galvanizing damaged by welding with corrosion resistant paint to match galvanized duct color.
- I. Ducts with minor axis less than 22" shall be spiral seam type. Larger ducts may be rolled, longitudinal welded seam type. SMACNA seams RL-2 and RL-3 are not permitted.
- J. Reinforce flat oval ducts with external angles. Internal tie rods are permitted only as indicated for rectangular ductwork.
- K. Transverse Joint Connections:
 - 1. Crimped joints are not permitted.
 - 2. Ducts and fittings 36" in diameter and smaller shall have slip joint connections. Size fitting ends to slip inside mating duct sections with minimum 2-inch insertion length and a stop bead. Use inside slip couplings for duct-to-duct joints, and outside slip couplings for fitting-to-fitting joints.
 - 3. Ducts and fittings larger than 36" shall have flanged connections.
 - 4. Secure all joints with at least 3 sheet metal screws before sealing.
 - 5. Slide-on flanges as manufactured by Ductmate Industries, Accuflange, or Sheet Metal Connectors are acceptable. Self-sealing duct systems are also acceptable (Lindab, Ward "Keating Coupling").

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2.06 FLEXIBLE DUCT

- A. Flexible duct shall be listed and labeled as UL 181 Class 1 Air Duct Material, and shall comply with NFPA 90A and 90B, and meet GSA, FHA and other U.S. Government agency standards. Flexible duct shall bear the ADC Seal of Certification.
- B. Flame Spread/Smoke Developed: Not over 25/50.
- C. Flexible duct shall have corrosion-resistant wire helix, bonded to an inner liner that prevents air from contacting the insulation, covered with minimum 1-1/2", 3/4 lb/cf density fiberglass insulation blanket, sheathed in a vapor barrier of metalized polyester film laminated to glass mesh.
- D. Inner liner shall be airtight and suitable for 6" WC static pressure through 10" diameter and shall be airtight and suitable for 4" WC static pressure 12" through 16" diameter. Outer jacket shall act as a vapor barrier only with permeance not over 0.1 perm per ASTM E96, Procedure A. "R" value shall not be less than 4.0 ft²*°F*hr/Btuh. Temperature range of at least 0-180°F. Maximum velocity of 4,000 fpm.
- E. Usage:
 - 1. Take-offs from supply ducts to inlets of terminal air boxes. Do not exceed 36" in length.
 - 2. Connections to air inlets and outlets. Do not exceed 6'-0" in length.
- F. Stretch all flexible duct to prevent sags and reduce air friction. Shorten and reinstall all sagging or loose flexible duct. Avoid sharp elbows. Elbows shall maintain 1.5 diameter centerline turning radius.
- G. Install per the SMACNA Flexible Duct Manual. Secure inner layer with draw band. Wrap with pressure sensitive tape for protection prior to installing draw band. Pressure sensitive tape alone is not acceptable.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Provide openings in ducts for thermometers and controllers.
- B. Locate ducts with space around equipment for normal operation and maintenance.
- C. Do not install ducts or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the electrical equipment. Unless intended to serve these rooms, do not install any ductwork or equipment in electrical rooms, transformer rooms, electrical closets, telephone rooms or elevator machine rooms
- D. During construction provide temporary closures of metal or taped polyethylene on open ducts to prevent dust from entering ductwork.
- E. Repair all duct insulation and liner tears.

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- F. Install manual volume dampers in branch supply ducts so all outlets can be adjusted. Do not install dampers at air terminal device or in outlets, unless specifically shown.
- G. Install flexible duct in accordance with the ADC Flexible Duct Performance and Installation Standards.
- H. Support all duct systems in accordance with the SMACNA HVAC Duct Construction Standards: Metal and Flexible and the SMACNA Seismic Restraint Manual: Guidelines for Mechanical Systems, where applicable. Refer to Section 23 05 50 for seismic requirements.
- I. Adhesives, sealants, tapes, vapor retarders, films, and other supplementary materials added to ducts shall have flame spread/smoke developed ratings of under 25/50 per ASTM E84, NFPA 255, or UL 723.

3.02 DUCTWORK APPLICATION SCHEDULE

USAGE	MATERIAL	PRESSURE CLASS	SEAL CLASS †	INSULATION (Refer to Section 23 07 13 for insulation types)
Supply Duct from Fan to Outlets	Galvanized Sheet Metal - Rectangular	+3"	A	1-1/2" thick Type A
Supply Duct from Fan to Outlets	Galvanized Sheet Metal - Round	+3"	A	1-1/2" thick Type A
General Exhaust Duct	Galvanized Sheet Metal	-3"	A	None
Ductwork Accessories (Fabric Flex Connectors, Equipment Flanges, etc.)	---	---	---	1-1/2" thick Type A
Duct Mounted Coil Headers	--	--	---	1-1/2" thick Type A
† Seal Class is per SMACNA HVAC Air Duct Leakage Test Manual				

3.03 DUCTWORK SEALING

- A. General Requirements:
 - 1. Openings, such as rotating shafts, shall be sealed with bushings or similar.
 - 2. All connections shall be sealed including, but not limited to, taps, other branch connections, access doors, access panels, and duct connections to equipment. Sealing that would void product listings is not required. Spiral lock seams need not be sealed.
 - 3. Mastic-based duct sealants shall be applied to joints and seams in minimum 3 inch wide by 20 mil thick bands using brush, putty knife, trowel, or spray, unless manufacturer's data sheet specifies other application methods or requirements.

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- B. For Seal Class A ducts, all transverse joints, longitudinal seams, and duct wall penetrations shall be sealed. Joints are inclusive of, but not limited to, girth joints, branch and sub-branch intersections, duct collar tap-ins, fitting subsections, louver and air terminal connections to ducts, access door and access panel frames and jambs, duct, plenum, and casing abutments to building structures.

3.04 TESTING

- A. Duct - 2" WG or Less (positive or negative):
 - 1. Systems shall not leak more than shown in Table 4-1 of SMACNA HVAC Air Duct Leakage Test Manual for Seal Class A.
 - 2. Leak testing of these systems is not normally required for interior ductwork. However, leak tests will be required if, in the opinion of the Architect/Engineer, the leakage appears excessive. All exterior ductwork shall be tested. If duct has outside wrap, testing shall be done before it is applied.
 - 3. Leak test shall be at the Contractor's expense and shall require capping and sealing all openings.
 - 4. Seal ducts to bring the air leakage into compliance.
 - 5. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing.
- B. Duct - 3" WG and Above (positive or negative):
 - 1. A minimum of 25% of interior ductwork and all exterior ductwork shall be tested. The Owner or designated representative shall select the sections to be tested. If duct has outside wrap, testing shall be done before it is applied.
 - 2. Leak test shall be at the Contractor's expense and shall require capping and sealing all openings.
 - 3. Seal ducts to bring the air leakage into compliance.
 - 4. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing.
- C. Test procedure shall be as listed in the latest edition of the SMACNA HVAC Duct Leakage Manual, with the following additional requirements:
 - 1. Test pressure shall be the specified duct pressure class. Testing at reduced pressures and converting the results mathematically is not acceptable. This is required to test the structural integrity of the duct system.
 - 2. If any leak causes discernible noise at a distance of 3 feet, that leak shall be eliminated, regardless of whether that section of duct passed the leakage test.
 - 3. All joints shall be felt by hand, and all discernible leaks shall be sealed.

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4. Totaling leakage from several tested sections and comparing them to the allowable leakage for the entire system is not acceptable. Each section must pass the test individually.
5. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing. Failure to notify the Architect/Engineer of pressure testing may require the contractor to repeat the duct pressure test after proper notification.
6. Upon completion of the pressure test, the contractor shall submit an air duct leakage test summary report as outlined in the SMACNA HVAC Duct Leakage Test Manual.
7. All access doors, taps to terminal air boxes, and other accessories and penetrations must be installed prior to testing. Including terminal air boxes in the test is not required.
8. The required leakage class for Seal Class A, both round and rectangular ducts, shall be 4.
9. Positive pressure leakage testing is acceptable for negative pressure ductwork.

3.05 DUCTWORK PENETRATIONS

- A. Seal all duct penetrations of walls that are not fire rated by caulking or packing with fiberglass. Install galvanized steel (unless otherwise indicated) trim strip to cover vacant

END OF SECTION 233100